Hydrology
of the Czech Republic

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Water on the Earth

- surface – 510 mil. km\(^2\) – 360,7 mil. km\(^2\) = 70,7% ocean

<table>
<thead>
<tr>
<th>Components of hydrosphere</th>
<th>Volume [thousands of km(^3)]</th>
<th>% of total amount of water</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ocean</td>
<td>1 360 000</td>
<td>97,6784</td>
</tr>
<tr>
<td>Glaciers + permanent snow</td>
<td>24 000</td>
<td>1,7237</td>
</tr>
<tr>
<td>Atmosphere (to 11 km)</td>
<td>13</td>
<td>0,0009</td>
</tr>
<tr>
<td>Freshwater lakes</td>
<td>130</td>
<td>0,0093</td>
</tr>
<tr>
<td>Salt lakes</td>
<td>105</td>
<td>0,0075</td>
</tr>
<tr>
<td>Artificial reservoirs</td>
<td>6</td>
<td>0,0004</td>
</tr>
<tr>
<td>Wetlands</td>
<td>6</td>
<td>0,0004</td>
</tr>
<tr>
<td>Rivers</td>
<td>1,25</td>
<td>0,0001</td>
</tr>
<tr>
<td>Soil moisture</td>
<td>25</td>
<td>0,0018</td>
</tr>
<tr>
<td>Water in aeration zone</td>
<td>40</td>
<td>0,0029</td>
</tr>
<tr>
<td>Water in saturation zone</td>
<td>8000</td>
<td>0,5746</td>
</tr>
<tr>
<td>TOTAL WATER SUPPLY</td>
<td>1 392 325,25</td>
<td>100</td>
</tr>
</tbody>
</table>

- Freshwater – only 3% (glaciers 79%, underground 20%, surface 1%)
Water on the Earth

**Longest rivers:**
- Amazon - 7 062 km
- Nile – 6 695 km
- Jang c‘t‘iang – 6 300 km
- Mississippi–Missouri – 6 275 km
- Yenisey-Angara-Selenga – 5 539 km

**Biggest glaciers:**
- Antarctica + Greenland = 98%
- Himalayas, Pamir, Cordillera and others only 2%

**Artificial reservoirs:**
- Bratsk (Angara) - 170 km³
- Asuan (Nile) - 169 km³
- Kariba (Zambezi) - 160 km³

**Biggest freshwater lake areas:**
1. American Great Lakes - 25% cca 32 500 000 km³
   (Lakes Superior, Michigan, Huron, Erie and Ontario)
2. African rift valley lakes – 22% cca 29 000 000 km³
   (Lakes Tanganyika, Victoria, Malawi, Albert, Edward etc.)
3. Baikal Lake – 18% cca 21 500 000 km³
Basic hydrographic characteristics of Czechia

- Czechia is situated in central Europe in the source area of European rivers (we are on the roof of Europe)
- Main European watershed contour come through Czechia – 3 separate sea-drainage areas:

<table>
<thead>
<tr>
<th>Sea</th>
<th>Catchment</th>
<th>Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>North sea</td>
<td>catchment of Labe</td>
<td>66.2%</td>
</tr>
<tr>
<td>Black sea</td>
<td>catchment of Dunaj</td>
<td>24.0%</td>
</tr>
<tr>
<td>Baltic sea</td>
<td>catchment of Odra</td>
<td>9.8%</td>
</tr>
</tbody>
</table>
Hydrographic and water management review

Total length of streams in Czechia 76 000 km
- basic net of streams (over 5 km²) 36 865 km
Streams important for water management 16 700 km
Small streams 59 300 km
Modified streams – 25% from total length 18 784 km
Lenght of artificial canals 578 km
Lenght of flood banks 586 km

Total volume of 114 big reservoirs (over 1000 m³) 3,141 km³
- water-supply reservoirs 0,934 km³
Total area of reservoirs (including small water bodies) 264 km²

<table>
<thead>
<tr>
<th>Name</th>
<th>Area [ha]</th>
<th>Depth</th>
<th>Volume [km³]</th>
<th>Year</th>
<th>River</th>
</tr>
</thead>
<tbody>
<tr>
<td>Orlík</td>
<td>2545,54</td>
<td>74</td>
<td>0,717</td>
<td>1960</td>
<td>Vltava</td>
</tr>
<tr>
<td>Lipno I</td>
<td>4909,76</td>
<td>22</td>
<td>0,306</td>
<td>1957</td>
<td>Vltava</td>
</tr>
<tr>
<td>Nechranice</td>
<td>1307,77</td>
<td>46</td>
<td>0,288</td>
<td>1968</td>
<td>Ohře</td>
</tr>
<tr>
<td>Slapy</td>
<td>1241,15</td>
<td>58</td>
<td>0,269</td>
<td>1955</td>
<td>Vltava</td>
</tr>
<tr>
<td>Švihov</td>
<td>1337,55</td>
<td>55,7</td>
<td>0,266</td>
<td>1968</td>
<td>Želivka</td>
</tr>
</tbody>
</table>
## The biggest rivers of Czechia

<table>
<thead>
<tr>
<th>River</th>
<th>Discharge (m³.s⁻¹)</th>
<th>Lenght of rivers (km)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Labe (Elbe)</td>
<td>308</td>
<td>Vltava 433</td>
</tr>
<tr>
<td>Vltava (Moldau)</td>
<td>150</td>
<td>Labe 357</td>
</tr>
<tr>
<td>Morava</td>
<td>115</td>
<td>Morava 352</td>
</tr>
<tr>
<td>Dyje (Thaya)</td>
<td>44,1</td>
<td>Dyje (Mor.) 304</td>
</tr>
<tr>
<td>Odra (Oder)</td>
<td>43,3</td>
<td>Ohře 291</td>
</tr>
<tr>
<td>Ohře (Eger)</td>
<td>37,9</td>
<td>Berounka (Mže) 239</td>
</tr>
<tr>
<td>Berounka</td>
<td>36,0</td>
<td></td>
</tr>
<tr>
<td>Otava</td>
<td>26,0</td>
<td></td>
</tr>
<tr>
<td>Sázava</td>
<td>25,5</td>
<td></td>
</tr>
<tr>
<td>Lužnice</td>
<td>24,4</td>
<td></td>
</tr>
<tr>
<td>Jizera</td>
<td>24,0</td>
<td></td>
</tr>
</tbody>
</table>
European largest river basins (without Russian rivers)
- Dunaj: 817,000 km²
- Visla: 194,000 km²
- Rýn: 183,000 km²
- Labe: 148,268 km²

Division of the Labe River
- Upper Labe River (Hirschstein) - 463 km
- Middle Labe River (Geesthacht) - 489 km
- Lower Labe River (North Sea) - 142 km

Spring of the Elbe River
- Krkonoše (Giant Mts.)
  - 1,384 m a.s.l.
- Labská louka (the Elbe meadow)
- Water level observations since 1851 – in Děčín
### the Labe River – growth of discharge [m\(^3\).s\(^{-1}\)]

<table>
<thead>
<tr>
<th></th>
<th>Vltava - mouth</th>
<th>Labe – confluence with Vltava</th>
<th>Labe - state border</th>
<th>Labe - North Sea</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Length [km]</strong></td>
<td>433</td>
<td>235</td>
<td>357</td>
<td>1094</td>
</tr>
<tr>
<td><strong>Discharge [m(^3).s(^{-1})]</strong></td>
<td>150</td>
<td>100</td>
<td>308</td>
<td>861</td>
</tr>
<tr>
<td><strong>Area [km(^2)]</strong></td>
<td>28 090</td>
<td>13 714</td>
<td>51 394</td>
<td>148 268</td>
</tr>
</tbody>
</table>

- **Vltava** 150
- **Ohře** 38
- **Outflow from Czechia** 308
- **Mulde** 67.5
- **Saale** 100
- **Outflow to the sea** 861

![Map of the Labe River](image)
the Vltava River - dams

- Czech longest river - 433 km
- Spring - 1 172 m a.s.l. Šumava Mts.
- „Vltava Cascade“ 9 dams
- regular water level observation in Prague since 1825

<table>
<thead>
<tr>
<th>River km</th>
<th>Name</th>
<th>Building</th>
<th>Volume tis. m³</th>
</tr>
</thead>
<tbody>
<tr>
<td>329,540</td>
<td>Lipo I</td>
<td>1952–1959</td>
<td>306 000</td>
</tr>
<tr>
<td>319,120</td>
<td>Lipno II</td>
<td>1952-1959</td>
<td>1 685</td>
</tr>
<tr>
<td>210,390</td>
<td>Hněvkovice</td>
<td>1986–1992</td>
<td>21 100</td>
</tr>
<tr>
<td>200,405</td>
<td>Kořensko</td>
<td>1986–1991</td>
<td>2 800</td>
</tr>
<tr>
<td>144,700</td>
<td>Orlík</td>
<td>1954–1966</td>
<td>720 000</td>
</tr>
<tr>
<td>134,730</td>
<td>Kamýk</td>
<td>1956–1962</td>
<td>12 800</td>
</tr>
<tr>
<td>91,694</td>
<td>Slapy</td>
<td>1951–1954</td>
<td>270 000</td>
</tr>
<tr>
<td>84,440</td>
<td>Štěchovice</td>
<td>1937–1945</td>
<td>11 200</td>
</tr>
<tr>
<td>71,325</td>
<td>Vrané</td>
<td>1930–1936</td>
<td>11 100</td>
</tr>
</tbody>
</table>

Bradáč – head of a bearded man (12th century) - from Judith bridge
the Vltava River - floods

Floods in Prague
- August 2002: max. discharge - 5 300 m$^3$.s$^{-1}$, max. water level – 785 cm
- July 2013: max. discharge – 3 210 m$^3$.s$^{-1}$, max. water level - 545 cm

Drought

Characteristics
- a random natural phenomenon caused mainly by rainfall deficit leading to a significant drop in water in various parts of the hydrological cycle (in the atmosphere, soil, watercourses, underground structures) and subsequently also in water resources
- water scarcity = water use requirements exceed available water resources

Types
• **Meteorological** - a prolonged time with less than average precipitation; precedes the other kinds of drought
• **Hydrological** - water reserves (aquifers, lakes, rivers and reservoirs) below a locally significant threshold (e.g. Discharge Q_{355} in 3 days); show up slowly; anthropogenic measures (landuse, wetland drainage etc.) can improve or worsen the situation

• **Agricultural** - soil drought, lack of moisture for crops; crop production affected; after meteorologicalvdrought; important role of agricultural management

• **Socioeconomic** – economic activities limited as a result of meteorological, agricultural or hydrological drought

Prevention: landuse, water bodies, wetlands
The driest years in Czechia (based on meteorological and hydrological observations, since the 20th century)

- 1904
- 1911 - summer lack of rainfall and higher temperatures
- 1917
- 1947!! - lack of rainfall and higher temperatures from April to October
- 1953-1954!!! - March 53 and from August to March 54 – lack of precipitation, very cold winter
- 1959 - lack of precipitation in autumn
- 1992
- 2000 - lack of precipitation in spring with higher temperatures for the whole year
- 2003 - lack of precipitation from February to September with high temperatures – also in Europe
- 2015 - summer and autumn, lack of precipitation from the beginning of the year, high temperatures, lack of snow, consequences several years
- 2018! - from April to November 2018, in lowlands till autumn 2019, low precipitation, high temperatures, problems in agriculture, water supply – private wells, measures taken for the population e.g.: ban on filling the pools, garden watering…
Outflow characteristics of Czechia

**Average annual outflow from Czechia = 0**

- $H_s =$ average annual sum of precipitation ($1 \text{ mm} = 1 \text{ litre on } 1 \text{ m}^2$) = 679 mm
- $H_o =$ average annual sum of surface outflow ($H_o = O/P - P$ of Czechia = 78 000 km$^2$) = 189 mm

$C =$ outflow coefficient ($c = H_o/H_s*100$) = 27.8%

**Extreme dry years (1947)**

- 436 mm

**Annual capacity of underground resources**

- Cretaceous sediments (Mesozoic era) = 1,44 km$^3$
- Quaternary sediments = 0,44 km$^3$/year
- Other (84% of area) = 0,42 km$^3$/year
- 0,58 km$^3$/year
Density of hydrological network in Czechia

- most of the rivers in the Czechia $0,1–3 \text{ km} \cdot \text{km}^{-2}$
  (average $\sim 1 \text{ km} \cdot \text{km}^{-2}$)
- data for catchments of following rivers:
  Labe $1,2 \text{ km} \cdot \text{km}^{-2}$
  Morava $1,1 \text{ km} \cdot \text{km}^{-2}$
  Odra $1,5 \text{ km} \cdot \text{km}^{-2}$
- mountain areas:
  $1,5–3 \text{ km} \cdot \text{km}^{-2}$
- lowland areas:
  $\sim 0,1 \text{ km} \cdot \text{km}^{-2}$
  (lower Dyje $< 0,2 \text{ km} \cdot \text{km}^{-2}$
  Pšovka $< 0,1 \text{ km} \cdot \text{km}^{-2}$)
Outflow characteristics of Czech rivers

Outflow (runoff) coefficient [%] \( c = \frac{H_o}{H_s} \times 100 \)

- various catchments differ between 10 – 60 %
- highest values in Moravsko-Slezké Beskydy Mts. (rivers Morávka, Ostravice),
- lowest values: tributaries of middle Labe (Pšovka), lower Vltava (Zákolanský p.) and lower Dyje (Kyjovka)

\( H_s \) = average annual sum of precipitation [mm]
\( H_o \) = average annual sum of surface outflow [mm]
Outflow characteristics of Czech rivers

Runoff unit-yield \([l\cdot{s}^{-1}\cdot{km}^{-2}]\) \(q = O/s*P\)

- in Czechia about 1–25 \(l\cdot{s}^{-1}\cdot{km}^{-2}\) (average value \(~6\ l\cdot{s}^{-1}\cdot{km}^{-2}\)
- the Labe River catchment \(6\ l\cdot{s}^{-1}\cdot{km}^{-2}\)
- the Morava River catchment \(4,5\ l\cdot{s}^{-1}\cdot{km}^{-2}\)
- the Odra River catchment \(10\ l\cdot{s}^{-1}\cdot{km}^{-2}\)
- headstream areas 20–35 \(l\cdot{s}^{-1}\cdot{km}^{-2}\) (Morávka, Olše, Ostravice, Morava, Labe)
- lowlands (central Polabí, lower Povltaví and Podyjí) \(~1–3\ l\cdot{s}^{-1}\cdot{km}^{-2}\), Dyje-Svratka revine \(~<1\ l\cdot{s}^{-1}\cdot{km}^{-2}\)
Hydrological regime of Czech rivers

Main sources of water:

- rain precipitations + snow melting
- complex outflow regime: *pluvio-nival* (subtype continental Europe)
- over altitude 800 m a.s.l. *nival-pluvial* regime

**Maximum discharge:** spring – snow melting + autumn rains; frequent floods in summer – storm rainfalls

**Minimum discharge:** lowlands and uplands in autumn (September); mountain areas at the end of winter (February)
Typical hydrological regime of Czech rivers

Discharge [m$^3$.s$^{-1}$]
Total outflow

Total outflow = surface outflow + underground outflow
Surface outflow – water level in rivers
Underground = Hypodermic outflow (Zone of Aeration) + Basal outflow (Zone of Saturatioin)
Basal outflow – water level in hydrogeological wells

The Vltava River - Praha
the Vltava River - Praha  the Morava River - Strážnice

the Odra River - Bohumín

Total outflow [mm]  Basal outflow [mm]
(underground)
### Consumption of water in Czechia 1965 - 1990

<table>
<thead>
<tr>
<th>Year</th>
<th>Consumption (km³)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1965</td>
<td>5.5</td>
</tr>
<tr>
<td>1970</td>
<td>7.7</td>
</tr>
<tr>
<td>1975</td>
<td>10.9</td>
</tr>
<tr>
<td>1980</td>
<td>15.5</td>
</tr>
<tr>
<td>1990</td>
<td>21.0</td>
</tr>
</tbody>
</table>

Water provided:
- 80% surface sources
- 20% underground sources

#### Usage of water – world 90s
- 5% drinking water
- 75% agriculture
- 20% industry

#### Usage of water – the Czech Republic 90s
- 38% drinking water
- 4% agriculture
- 32% industry + services
- 26% energetics

- developed countries:
  - diminution of water usage of about 25% during last 20 years
Water use in Czechia

Since 1993 – decline of water usage per capita:
1993 – 343 l/capita/day  
2000 – 245 l/capita/day  
2016 – 132 l/capita/day  
2019 – 91 l/capita/day

Decline of water consumption according to sectors during the years 1990 – 1999:
- Agriculture – 88 %
- Industry – 47 %
- Energetics – 48 %,
- Drinking supply – 34 %

Main reasons:
- Decrease of industrial and agricultural production,
- Environmental technologies,
- Price of water (2016 – water & sewage 37 Kč/m³ & 32 Kč/m³)
Hydrological management in Czechia

**Main authorities for water law:**
Ministry of Agriculture – National Plan, water management in the Czech Republic
Ministry of Environment - National Parks, protected areas
Ministry of Health – limits for drinking water, bathing norms
Ministry of Transport - navigation
Ministry of Defense – water as a strategic resource

**Executive and monitoring role:**
- the Labe River Authority – [http://www.pla.cz](http://www.pla.cz) (Hradec Králové) 14 976 km²
- the Morava River Authority – [http://www.pmo.cz](http://www.pmo.cz) (Brno) 21 133 km²
- the Vltava River Authority [http://www.pvl.cz](http://www.pvl.cz) (Praha) 27 580 km²
- the Ohře River Authority – [http://www.poh.cz](http://www.poh.cz) (Chomutov) 10 098 km²
- the Odra River Authority – [http://www-pod.cz](http://www-pod.cz) (Ostrava) 7 246 km²
- Forests of the Czech Republic- [http://www.lesycr.cz](http://www.lesycr.cz) (Hradec Králové)
  - 94 % of streams
  - 6 % municipalities, national parks, military areas
Hydrological monitoring in Czechia

Monitoring
Czech Hydrometeorological Institute & River Authorities
- stable profile network + special-purpose profiles
- water level measurement – gauging stations
- water quality sampling
- sediment & suspended matter sampling, biota sampling (benthos, fish)
- forecasts, assessment, measures

T.G.M Water Research Institute ASCI ČR, Research Institute for Soil and Water Conservation ASCI ČR, Czech Geological Survey, universities, Environmental institutions, nongovernmental organisations etc...

DATA:
Information portals:
The water management information portal (Ministry of Agriculture)
www.chmi.cz – Czech Hydrometeorological Institute
Flood forecasting service (CHMI) http://hydro.chmi.cz/hpps/index.php
Surface water quality profiles
Groundwater monitoring profiles